SMART CARD AND READER/WRITER

Field of the Invention

The invention relates to an improved smart card and in particular, but not limited to, a smart card with a first serial data interface and at least one second data interface. The invention also relates to a reader/writer for reading or writing information to such a smart card, to an electronic book for use with such an improved smart card, and to an adaptor card for use with such a reader/writer.

Background of the invention

Conventional smart cards, such as those conforming to International Standard ISO 7816, are used for secure data storage but are limited in the amount of data that can be stored on the smart card. In order to conform with the ISO standard, integrated circuits within a smart card should be located under contact areas on the surface of the smart card. Also, the interface of conventional smart cards, such as those conforming to the ISO standard, are limited with respect to the speed with which information can be read from that smart card.

In the international standard and conventions agreed for Smart Card protocols, in particular ISO7816 parts 1-6, a serial data interface as defined in the ISO7816 standard is used for accessing data from integrated circuits on the smart card. This arrangement is only satisfactory for the limited amount of data transfer necessary to carry out the security code functions and limited data transfers in conventional Smart Card applications. For example, library access cards, telephone cards and identification cards. Also, when data is accessed from a conventional smart card using the ISO7816 standard, the control data for operation of the smart card protocol must also be communicated between the smart card and a smart card reader. This means that not only is the data transfer rate limited by the interface

design but also the actual data transfer rate (not including control data) is limited by the need for the control data.

For example, smart cards have been tested for use in biometric systems in which individuals are issued with a smart card containing personal information about that individual. For example, medical records, fingerprint records and other personal details. However, the use of smart cards for this purpose has been unsuccessful to date, because the storage capacity of the smart cards has been too small.

The present invention also relates to electronic books for use with smart cards and some background information about electronic books is now given. Electronic books comprising a memory for storing text and graphical information and a display screen for displaying this information are known, for example as described in WO/9722065. This document discloses a portable, hand-held reading device which incorporates a removable machine-readable storage medium such as a smart card or PCMCIA card (also known as a PC card). However, one problem with PCMCIA cards is that they are relatively expensive to manufacture, especially in the case that single-use applications are required. For example, where a book is recorded on a PCMCIA card and that PCMCIA card is not intended to be erased and used again to store a different book at a later time.

Smart cards are less expensive to produce than PCMCIA cards and are simpler and often less bulky. However, conventional smart cards do not contain enough memory to store a typical book. For example, a book may take up 4 Mb of memory whilst a conventional smart card only contains between about 256 bytes to 8 k bytes of data storage capacity. Another problem is that conventional smart card readers (such as those designed to conform to the smart card interface standard ISO 7816) are limited with respect to the speed in which data from the smart card can be read. That is, even if a smart card were able to store a whole book, it would not be possible to read this information quickly enough from the smart card using a conventional smart card reader.

Other types of electronic book, such as that described in US 5475399, use CD ROMs or floppy disks to store the book contents. However, the reader mechanisms contained in the electronic book must then incorporate moving parts which are prone to damage, especially in a portable display device. CD ROM readers and hologram readers (for example, US 4159417 describes an electronic book which uses a hologram storage mechanism) involve light sources or lasers and these are also difficult to maintain and operate in a portable display device like an electronic book.

Another option is to use an electronic book which contains its own memory and where information for the book contents is downloaded from a Personal Computer (PC) or the Internet (for example, see US 5761485). However, this has the disadvantage that the user needs to be able to operate the PC or know how to obtain information from the Internet. Also, downloading information in this way is time consuming and prone to problems, for example, if the internet connection is lost during the download process.

A significant problem for data storage involves security. For example, personal data stored on security or identity cards needs to be kept confidential and material that is subject to copyright or other intellectual property rights should not be copied without authorisation. However, at present, few simple and effective methods are available for managing confidential information and information that is subject to copyright.

It is accordingly an object of the present invention to provide a smart card which overcomes or at least mitigates one or more of the problems noted above. Another object of the present invention is to provide a smart card reader/writer which overcomes or at least mitigates one or more of the problems noted above.

Summary of the Invention

According to a first aspect of the present invention there is provided a smart card comprising:

- A sheet of supporting material;
- an electrical contact means provided on said sheet of supporting material and adapted to provide an electrical contact with a smart card reader in use;
- one or more integrated circuits supported by said sheet; and
- interface means comprising a first serial data interface and at least one second data interface which may be serial or parallel arranged such that in use, data stored in said integrated circuits may be accessed via said second data interface.

This provides the advantage that data transfer from the smart card is increased relative to a conventional smart card, by virtue of the data interfaces. Also, because a first serial data interface is provided, the smart card can still be used with a conventional smart card reader. Once the data transfer rate is increased in this way it is possible to incorporate more memory capacity into the smart card whilst still being able to access data stored in this extra memory in a practical time. The resulting smart card provides a cost-effective solution for efficient, secure storage and retrieval of relatively large amounts of data (as compared with a conventional smart card) on a conveniently sized, portable medium.

Preferably said integrated circuits are positioned below said contact means. This allows the improved smart card to conform with the ISO 7816 requirement that the integrated circuits be positioned below the contact pads.

According to another aspect of the present invention there is provided a smart card reader/writer suitable for reading data from or writing data to a smart card comprising a first serial data interface and a second data interface which may be serial or parallel, said smart card reader comprising: interface means adapted to communicate data with said first serial data interface and said second data interface

in use and wherein said interface comprises an electrical contact means adapted to provide an electrical contact with said smart card in use.

This provides the advantage that data can be accessed from or written to an improved smart card at relatively high rates using the data interfaces, as compared with a conventional serial data interface for an ISO 7816 smart card reader.

According to another aspect of the present invention there is provided an adaptor card suitable for use with a smart card reader/writer as claimed in any of claims 15 to 25 said adaptor card comprising:-

(i) a first interface arranged to allow communication between said adaptor card and said reader/writer in use;

(ii) a second interface arranged to allow communication between said adaptor card and another device in use; and

(iii) an integrated circuit arranged to convert data between formats suitable for said first and second interfaces.

For example, in the case that a reader/writer for an improved smart card is incorporated into an electronic personal organiser, then an adaptor card may be inserted into that reader/writer and used as a type of adaptor plug to allow the personal organiser to be connected, via the adaptor and reader/writer, to another device, such as a mobile telephone or a personal computer. Different types of adaptor cards would be used to connect the device hosting the reader/writer to other devices. This provides the advantage that a convenient, small and inexpensive adaptor is available to allow a variety of other devices to be connected to host devices.

The invention also encompasses an electronic book containing such a smart card reader and an electronic book comprising a removable smart card storage means wherein the smart card is as described above. The invention further encompasses a portable hand-held audio player comprising a smart card reader where the smart card reader is as described above.

Bri f description of the drawings

Figure 1 is a plan view of an improved smart card.

Figure 2 is a general schematic diagram indicating the electrical connections of an improved smart card interface.

Figure 3a is a plan view of an improved smart card which has two interfaces.

Figure 3b is a side view of the improved smart card of figure 3a.

Figure 4 is a schematic diagram of an improved smart card interface.

Figure 5 is a schematic diagram of an improved smart card interface with octagonal ground planes.

Figure 6 is a schematic diagram of an improved smart card interface with circular ground planes.

Figure 7 is a perspective view of an electronic book for use with an improved smart card.

Figure 8 is a schematic illustration of the functional blocks of electronics comprised with the electronic book of Figure 7.

Figure 9 is a plan view of a smart card reader/writer part of which is cut away to show an improved smart card in the card reader/writer.

Figure 9a is a cross-section along line A-A' of Figure 9.

Figure 9b is a cross-section along line B-B' of Figure 9.

Figure 10 is a general schematic diagram of the smart card reader/writer of Figure 9.

Figure 11 is a general schematic diagram of an adaptor card suitable for use with the smart card reader/writer of Figures 9 and 10.

Detailed description of the invention

Embodiments of the present invention are described below by way of example only. These examples represent the best ways of putting the invention into practice that are currently known to the Applicant although they are not the only ways in which this could be achieved.

Figure 1 is a plan view of an improved smart card 101 which comprises a sheet of supporting material 102 such as a thermoplastics card within which integrated circuits are embedded (not shown). The improved smart card 101 has a contact means 103 which comprises two contact areas or pads 104, 105. These contact areas also represent the interface means. In a preferred embodiment the integrated circuits are located only under the contact areas or pads. By including two contact areas or pads 104, 105 the available area under which integrated circuits can be located is increased. Additional integrated circuits are provided as compared with an ISO 7816 smart card, in order to increase the memory capacity available.

One of the contact areas 104 comprises a serial data interface such as those conforming to the ISO 7816 standard. The other contact area 105 comprises a parallel data interface as described below. It is also possible to use more than one parallel data interface by positioning extra parallel data interfaces on the support surface 102 around serial data interface 104.

Figure 2 shows example electrical connections within each contact area 104, 105 in more detail. Each contact area 104, 105 comprises a ground connection a, b, and these are connected to one another. For this reason it is advantageous to position the contact areas 104, 105 next to one another, but this is not essential.

Figure 3a is a plan view of a smart card which has one interface means 301 positioned at one end of the support sheet and another interface means 302 positioned at the other end of the support sheet. Also, the interface means 301, 302 are on opposite sides of the support sheet as shown in Figure 3b.

The improved smart card described herein augments the 'Smart' interface as in ISO 7816. The improved smart card enables parallel data transfers between a Credit Card sized (86mm x 54mm) standard card and a host reader. This increases data transfer through the interface by at least eight times the speed of existing serial interfaces (such as those conforming to ISO 7816 standard), for the same clock speed at the interface.

The improved smart card gives a sampling rate at one byte instead of the conventional one bit per clock serial data transfers of smart cards conforming to ISO 7816 standard. This enables the improved Smart Card to carry out more complex assignments and broadens the generic use of the improved smart card as an information source.

In one embodiment, the improved smart card also contains increased storage capacity as compared with the 256 bytes to 8k bytes (typical) of data storage capacity normally available in a Smart Card. This enables the improved smart card to act as a replacement for text books, catalogues containing pictures, audio tapes, CD ROMs, PCMCIA memory cards, floppy disks, camera cards and other optical, magnetic, and electronic media for data storage.

When the storage capacity within the improved smart card is increased it is particularly advantageous to reduce data transfer times between the Smart Card and host reader. This is achieved using a parallel interface which enables a faster data transfer rate to be accomplished using the existing serial clock rate. If required, a higher clock rate can also be used which further increases the data transfer rate. In this case, the ISO 7816 protocol clock speeds may not be met, but this is acceptable for non ISO applications.

In one example, the improved smart card has similar external dimensions as a conventional Smart Card and utilizes the contact pad protocols of the ISO 7816 standard to position the serial port interface. In addition an adjacent interconnected contact pad is provided to allow transmission of parallel information.

In one example, the serial data interface consists of an ISO 7816 eight pin interface and the parallel data interface comprises a further eight pin interface. The resulting interface means consists of sixteen pins in total, and occupies an area of double the width of the normal ISO 7816 interface.

A ground connection at pin 5 (see Figure 2) of the serial data interface is extended across via the centre of the serial data interface contact area 104 to the

centre of the parallel data interface contact area 105. Detection of a ground connection at the centre of the parallel data interface contact area 105 distinguishes the improved smart card, from a normal ISO 7816 interface. This does not affect the integrity of the ISO 7816 interface connections.

The new eight pins (9 to 16 in Figure 2) comprising the parallel data interface are connected to the data bus of memory circuits (integrated circuits) internal to the Smart Card. Thus, once data transfer has been initiated, the data can be transferred one byte (eight bits) at a time compared to the one bit at a time over the serial connection at pin 7 (see figure 2) of the normal ISO 7816 interface. The data transfer in both cases is synchronous with the data clock, which is present at pin 3 (see figure 2) of the normal ISO 7816 interface.

As the actual data accessed from the smart card data is embedded within the serial data protocols of the ISO 7816 standard, the true user-data transfer rate is considerably slower than the possible serial clock rate. Once data transfer has been initiated, the interface means 103 transfers data at eight times the serial clock rate. Thus user-data transfer is at a much greater rate than the normal ISO 7816 standard allows, and the integrity of the ISO 7816 standard is not compromised.

The existing ISO 7816 standard pin numberings and functions of the normal interface are retained in the serial data interface. The additional pins of the parallel data interface are numbered 9 through to 16, and correspond to data bits 1 through to 8 of the data bus connections (i.e. an eight-bit wide data bus). The new pins of the parallel data interface are numbered in the same fashion as the pins 1 through to 8 of the serial data interface. Thus pin 9 of the Second Part is adjacent to pin 4 of the First Part, and pin 13 of the Second Part is adjacent to pin 8 of the First Part. (See Figure 2).

The serial data interface can be arranged to provide a means of authentication. That is, on use of the improved smart card, a smart card reader first communicates with the smart card via the serial data interface and checks security

details stored in that smart card (for example a personal identification number). Then, once authentication is successfully completed, data on the smart card can be accessed via the parallel data interface. Similarly, new data can be written to the smart card via the parallel data interface.

Figure 1 shows the position and proportions of the interface means 103 relative to the Smart Card 101. The position of the serial data interface, for example an ISO7816 standard interface 104 is shown in Figure 1. Adjacent to this, and maintaining the same contact separation as the contacts of the serial data interface 104, is the parallel interface 105. This comprises a further eight contacts, the minimum contact pad proportions and dimensions of which conform to the detail dimensions of the contact pin connections of ISO7816, but are positioned adjacent to the existing interface serial interface 104. The serial and parallel data interfaces 104, 105 comprise the interface means 103.

Figure 2 shows the electrical connections of the interface means 103. Pins 1 to 8 conform to the ISO7816 standard and have the same numbering and pin functions. Pins 9 to 16 correspond to the parallel data bits one to eight respectively. The existing 'ground' contact at pin 5 of the serial data interface 104 is extended through the physical centre of the serial data interface 104 - see figure 2, Pin 'a', to the physical centre of the parallel data interface - see figure 2, Pin 'b'. The contact pad areas 'a' and 'b' represent the minimum areas which must be available as 'ground ' connections to the centres of interfaces 104, 105. Thus pin 5 of the existing ISO7816 interface is electrically and mechanically connected to pins 'a' and 'b' of interfaces 104 and 105.

The interface reader (not shown) makes an external 'ground' connection at pin 5, as in a conventional Smart Card reader. Detection of a 'ground' at pin 'a' only indicates a conventional Smart Card has been inserted into the reader. Detection of a 'ground' at pins 'a' and 'b' indicates an improved smart card has been inserted.

The smart card 101, conventionally is a flat planar rectangular surface, of nominal thickness 0.3mm to 1.00mm. In current usage the ISO standard requires the longitudinal axis to be inserted into a reader port. The electrical apparatus as described herein is not restricted to the convention and may be inserted into an appropriately engineered transverse axis port.

Figure 3 shows various positions that interface means 103 may be located on the smart card 101. It is possible to position an interface means 103 at either or both ends of the card and on one or both sides or faces of the card. It is possible, with two opposing read heads, to read both sides of a card at the same time, or contiguously. The preferred positions are with one interface means 103 at each end of the card, on opposing sides. This requires only a single read head. Thus the card is inverted longitudinally to utilize the second interface.

Figures 4, 5, & 6 show different physical implementations of the contact areas of the interface means 103. Figure 4 depicts an interface means 103 constructed in rectangular form, about a central rectangular 'ground' plane. Figure 5 depicts an interface constructed about octagonal centres of the 'ground' planes in the two contact areas 104, 105, using connector pins having angled edges. Figure 6 depicts an interface constructed about circular centres of the 'ground' planes in the two contact areas 104, 105, using connectors having curved edges.

The improved smart card is constructed, for example, by bonding the integrated circuits to the back of the contact pads and epoxy bonding the integrated circuits into a milled out recess in the sheet of supporting material. Any other suitable method of construction may be used. An alternative method of construction may comprise a flexible PCB with memory and control circuits. Internal dies of integrated circuits are used and are attached direct to the flexible PCB. The whole PCB is then encapsulated between two outer layers of the smart card 717, thus providing protection for the PCB whilst allowing a limited degree of flexibility, as in known uses of smart cards, such as phone cards. Electrical contact pads are

provided on the external surface of the smart card. This construction method enables more memory dies to be incorporated within the smart card to increase the memory capacity of the smart card.

It is not essential to use semiconductor devices to provide the memory within the smart card. Alternative types of memory device can be used, such as the recently developed 3D memory storage system which uses metal alloys and gives vast increases in memory capacity for small amounts of storage space. Integrated circuits may still be used in conjunction with the 3D memory storage system to control access to that memory system.

Referring now to figures 7 and 8 an electronic book 710 is described which is suitable for use with an improved smart card. The electronic book 710 takes the form of a "smartbook" being intended to be used in a similar fashion to a paperback book, that is to enable the user to read a book such as a novel or guidebook.

The electronic book 710 preferably has dimensions similar to those of a paperback book, e.g. 125mm by 200mm by 25mm, and may conveniently be provided in a folding wallet for ease of use. The electronic book 710 comprises a casing 711, and on its front face a display and input screen 712 , for example with a diagonal of 195mm. The casing 711 is preferably formed from one or more plastic moldings. The display and input screen 712 may be of any appropriate kind, for example known liquid crystal kind with backlight, and comprising touch sensitive input means.

The resolution of the display screen 712 is sufficient for the display of text such that it is readily readable by the user. A horizontal resolution in accordance with existing VGA standards is appropriate. A vertical resolution of the same standard may be used, alternatively it may be 1 5/8 VGA standard in order to give an aspect ratio of 8 by 13, which corresponds to the layout of most conventional paperback books. This results in a screen resolution of 640 by 1040 pixels.

The touch sensitive input means incorporated in the display and input screen 712 may comprise however many sensitive points that are required to provide

"softkeys" for control of the functions provided by the electronic book 710. In one example, no more than 40 horizontal and 40 vertical sensitive points are required.

The electronic book 710 further comprises, provided within the casing 711, a printed circuit board (PCB) providing the necessary electronic circuitry, in the form of a microprocessor 713, memory 714 and interface means 715 to communicate between the display and input screen 12 and the other parts of the electronic circuitry. In one example, the electronic book 710 uses a relatively slow microprocessor, as the faster the processor the greater the power consumption, and therefore the shorter the battery life, and the greater the heat loss and therefore greater need for cooling perhaps necessitating fans. A microprocessor with a clock frequency of 50 MHz or less, possibly as low as 10 MHz, would be appropriate.

The memory 714 within the electronic book 710 comprises several different memory elements; a screen memory, a main data-storage memory and a main programmable memory. The screen memory will preferably comprise static RAM (Random Access Memory) which retains the data therein so long as a voltage is applied, in order that the last-used-screen is automatically displayed on switch-on. The main data-storage memory is conveniently flash memory in order that it retains the data therein without any requirement for power, hence retaining the memory even if the batteries are changed or they lose their charge. Preferably the main data-storage memory is sufficient for the storage of eight average length books, that is 32 Megabytes. The main programmable memory is conventional PROM (Programmable Read Only Memory) form, and may be socket mounted for ease of replacement or upgrade. Alternatively, the main programmable memory may be flash memory.

The casing 711 comprises a slot 716 for receipt of an improved smart card 717 bearing recorded data, and when in the slot 716 the smart card 717 makes connection with contacts provided on the PCB and hence connection to the interface means 715 for reading of the data stored thereon. The improved smart card 717 is

preferably a smart card with a serial and a parallel data interface and an increased memory as described above. The electronic book comprises a smart card reader which is suitable for reading data from this improved type of smart card.

The casing 711 also comprises a compartment adapted for receipt of one or more batteries as necessary to power the apparatus. Preferably separate batteries are provided to power the electronic circuitry and the backlight. However, the circuitry will preferably ensure that power is maintained to the screen memory whichever batteries are removed or lose charge, in order to retain a "last-screen-used" function. An on/off switch 718 is also provided.

In one example, the electronic book 710 operates as follows. When a smart card 717 containing the contents of a book is introduced in to the slot 716 the data is read into one of eight software defined portions of the data-storage memory using a parallel data interface on the smart card 717 and the smart card reader in the electronic book. To minimize the time taken for the book to be available to the user the data may be stored on the card in a specific order, which varies depending on the type of book. For example, for a guide or reference book, first the title page and frontispiece, then the contents page, then the first page of each chapter, and then the remaining portions of each chapter. Thus while downloading of the remaining portions of each chapter from the smart card 717 the apparatus is able to display the contents and first pages to aid selection.

Various functions such as being able to enter bookmarks are available to the user. On switch-on the user is offered a number of choices, such as, last page used, bookmarked page, or a set-up page offering other options such as changing book. Options of display font, and font size along with using the screen 712 in portrait or landscape mode may also be provided. Clearly if the selected display mode is such that the whole page of text is not visible on the screen at one time then the ability to scroll the display horizontally and vertically is available.

If eight books are already stored within the data-storage memory then if another smart card 717 is input into the slot 716 the option of which book to overwrite is available.

The smart cards 717 for use with the electronic book 710 are improved smart cards containing a parallel data interface. They may take one of two forms, either one-time-programmable or re-usable, as is now described.

One-time-programmable smart cards 717 are passive storage devices comprising non-volatile memory and controlled, once inserted into the electronic book 710, by the electronic book 710. They provide a cheap form of data storage with the cost of the smart card itself being a fraction of the selling price of the smart card once programmed. The smart cards 717 may be sold pre-programmed or may be programmed at the point of sale. The latter option enables retailers to stock empty cards and program these on demand thus avoiding much waste, as currently occurs when books are recalled for pulping when sales have been poor. Once programmed the smart cards cannot be overwritten, but can be read a number of times, and as collected form a compact library.

The second form of smart card is the re-usable form. This form has the same physical construction as the one-time programmable form and interfaces with the electronic book 710 in the same way as previously described. In place of non-volatile memory, flash memory, that is dies of re-writable integrated circuits is used.

The re-usable smart card 717 is intended for ephemeral publications rather than for books. For example, for newspapers, magazines or other periodicals. The additional cost of this smart card is offset by its flexibility, as data may be written and rewritten to the same smart card a large number of times. A user of the electronic book 710 could have one or more smart cards and take them to be re-written each day in place of buying a physical newspaper, or each week or month instead of buying a physical magazine. Alternatively, an internet connection may be used to download the data to the smart card.

In the examples described above the improved smart card comprises an interface means with a first serial data interface and a second parallel data interface. For example, the serial data interface comprises an 8 pin port conforming to the ISO7816 standard and communicates with a smart chip located under that 8 pin port on the smart card. The parallel data interface also comprises an 8 pin port (byte-wide), for example. This is located adjacent the serial 8 pin port and communicates with memory chips located under that 8 pin port. However, it is also possible to configure the second data interface as a serial rather than a parallel data interface. In this case the 8 pin port of the second data interface is configured in a similar way as that for the ISO7816 port. Table 2 below lists the electrical connections that would be used for the 16 pins in the case that both ports are serial. Table 1 below lists these same connections in the case that one serial and one parallel port are used. The type of memory incorporated within the improved smart card determines the configuration of the port. The interface electronics is required to validate data transfers and to communicate with the appropriate pins for the memory type being used.

It is possible, for example, to utilise the extra eight pins, configured as a serial port, to house a further 'Smart' chip if necessary. There are few practical advantages to doing this, as Smart chips do not contain large amounts of memory. However, with the growing use of Mobile Phone technology in applications such as remote collection and storage of electronic mail (e-mails), and for electronic transactions (e-commerce), there is a need for increased memory in Mobile Telephones. Some manufacturers are starting to include two SIMs (Subscriber Identity Modules) in their telephones. While this configuration could also be achieved under one platform with the Improved Smart Card, there are greater benefits in using a card with much larger memory capacity, with the memory access controlled by a single 'Smart' chip.

The Improved Smart Card and its associated reader/writer offer just such benefits. Due to its construction, it would be possible to supply the card in a form

whereby the functioning contact pad area could be separated from the remainder of the card. That is the size of the improved smart card is reduced by removing most of the supporting sheet or card. The remaining small module may then be inserted into a small, shortened version of a reader/writer in exactly the same manner as that of conventional small telephone SIMs. This means that Mobile Telephones are instantly equipped with large, removable, and secure, memory means, enabling their use for many more applications than are currently possible, such as remote downloading of MP3 music files, or E-mails with large file attachments.

Further details of a reader/writer for use with the improved smart card described above are now given.

Figure 9 shows a smart card reader/writer suitable for use with an improved smart card. The reader/writer has a housing 1004 which is rectangular and has a slot into which at least part of an improved smart card can be accommodated. Figure 9 shows an improved smart card 1001 which is inserted into a slot in the housing 1004. A card indicator switch 1002 is located in the housing in such a position that it is activated by a smart card when it is inserted into the housing. More such card indicator switches may be used but only one is shown in Figure 9. Supported by the housing 1002, on the interior surface of the housing, are a plurality of electrical contact pins 1003. In the example shown in Figure 9, sixteen such pins are used and these are positioned such that they contact corresponding contact regions (such as those illustrated in Figure 2) on an improved smart card 1001 when that card is inserted in the housing. Similarly two electrical contacts 1005 are provided for contacting the 0 volt or ground plane connection regions on the improved smart card. In figure 9, reference numeral 1006 is used to refer to the contact region on the improved smart card itself. This corresponds to the contact region C in Figures 1 and 3A.

Figure 9a is a cross-section along line A-A' of Figure 9 and Figure 9b is a cross-section along line B-B' of Figure 9. The same reference numerals are used to refer to corresponding components in Figures 9, 9a and 9b.

Figure 10 is a general schematic diagram of a smart card reader/writer suitable for use with the improved smart card described herein. The housing assembly of the reader/writer is indicated by reference numeral 1007 and an interface 1023 for communicating with the first serial data interface of the smart card is shown together with a second interface 1024 for communication with the second data interface of the smart card. For example, the first interface 1023 comprises an 8 pin connector for contacting an 8 pin ISO7816 port on the smart card that accesses a smart chip in the smart card. For example, the second interface 1024 comprises an 8 pin connector for contacting an 8 pin parallel port on the smart card that accesses a memory chip in the smart card.

The smart card reader/writer further comprises an electrical connection 1008 from the ISO port interface 1023 to a central processing unit 1010. There is also an electrical connection 1009 from the additional port interface 1024 to the same central processing unit 1010. The central processing unit comprises electronic circuitry to arbitrate and control the flow of data between the card reader/writer and devices to which the card/reader writer is connected.

The smart card reader/writer is typically incorporated into another device such as a personal organiser, mobile telephone, personal computer or other apparatus. This other device is termed a "host" and an electrical connection 1011 is provided between the central processing unit 1010 and a port on that host 1012. For example, if the host is an electronic book, data read from the smart card is passed via connection 1009, central processing unit 1010, and connection 1011 to the host device.

Figure 11 shows an adaptor card for use with the reader/writer described herein. The adaptor card has a similar shape as a smart card (although it may be

longer) in order that the adaptor card may be inserted into a smart card reader/writer. The function of the adaptor card is to allow the host device to be connected to other devices via the reader/writer. For example, if the host device is a personal organiser which incorporates a reader/writer then an adaptor card can be used to allow another device such as a mobile telephone to be connected to the host device. Thus a connector 1014 is provided on the adaptor card for connection to another device. This connector 1014 may be a PCMCIA connector, a USB connector, an RS232 connector, a parallel port connector, a connector for an IEEE 488 bus or any other suitable type of connector.

The adaptor card 1017 also has an interface for communicating with the smart card reader/writer. This comprises a contact film 1022, an ISO7816 interface 1020 and an additional port 1021. Internal electrical connections 1019, 1018 are provided from a controller integrated circuit 1016 to the ISO interface 1020 and to the additional port 1021. The function of the controller integrated circuit is to translate or convert the format of the data between the formats required by each of the host device and the other device to which the adaptor card is connected. The controller integrated circuit 1016 is also connected to the connector 1014 for connecting the adaptor card to another device.

More details about the reader/writer assembly are now given:

<u>Physical Card reader/writer</u>

The physical card reader/writer consists of a card reader/writer that conforms to the overall dimensions of similar card readers intended for ISO7816 Smart cards. It consists of a physical card-holder with provision for a card conforming to ISO7816 to be inserted into a slot in said card holder, and with supporting material for sets of electrical contacts.

It differs from the conventional Smart card reader/writer in that it consists of a set of sixteen electrical contact pins, arranged such that said contact pins are in alignment

with the sixteen contact pads on the Improved Smart Card when the card is pushed fully home into the locating slot. The conventional Smart card reader has only eight contact pins, and variations have only six contact pins, as two of the eight pins used in the ISO7816 standard configuration have yet to be assigned usage.

The first eight pins of the Improved Smart Card reader/writer are situated in exactly the same position as the eight pins of a conventional Smart card reader/writer. The extra eight pins of the Improved Smart Card reader/writer are situated adjacent to the first eight pins, towards the centre of the card. The sixteen interface pins are positioned such that they contact the sixteen contact pins/pads of the Improved Smart Card, when the card is inserted into the reader/writer slot and pushed fully home.

The physical card reader/writer may, or may not, also contain a set of two further contact pins arranged such that said two contact pins make contact with the extended 'Ground' contact pad running across the centre of said Improved Smart Card contact pad area. One contact pin may be positioned in the physical centre of the conventional eight-pin interface described in ISO7816. The second pin may be positioned in the physical centre of the additional eight-pin interface that constitutes the 'Improved' part of said Improved Smart Card.

Thus, the reader/writer arbitration, said Central Processing Unit, is able to discriminate whether a standard Smart card or an Improved Smart card is present. This may be achieved before the main sixteen interface pin connections are powered up and any data is transferred, by checking for a 'ground' connection at each of said two further pins. A 'ground' connection at the centre of the standard ISO port only; confirms a standard Smart card has been inserted into the reader/writer. A 'ground' connection at both the centre of the standard ISO port, and the centre of the

additional eight-pin interface, confirms that an Improved Smart card has been inserted into the reader/writer. Thus the generic card type is determined, by checking for 'grounds' at the centre pad interface connections, before the card is physically powered.

The physical reader/writer also contains an additional pair of electrical contacts arranged in the form of a switch. Said switch contacts are normally 'open', (not in contact), with no card inserted in the reader/writer. When a card is inserted and pushed fully home, the switch contacts are closed together, making electrical contact. This connection is used by the reader/writer's electronics, to power up the connections to the card interface pins. This is done in a specific order, ensuring that power to the Voltage supply to the card is supplied first, followed by connections to the remainder of the pins. This ensures that none of the contacts of the card, especially the Improved Smart card, is powered up before the main supply to that card, ensuring that none of the circuitry within the card is reverse-biased, thereby preventing potential internal damage to the embedded circuitry.

Further details about the central processing unit in the smart card reader/writer are now described. This central processing unit provides so called "arbitration means" to enable the secure transfer of data to and from the memory on an improved smart card.

<u>Data arbitration and processing</u>

The arbitration means incorporated in the reader/writer are to enable the secure transfer of data to and from the memory on the card. The arbitration procedure is capable of implementing many levels of authentication and validation processes, depending on the degree of security required for the stored data. If the data files relate to, for instance, personal biometrics, or financial transactions, a much higher

level of security is needed than for, say, personal letters on a computer-storage memory card.

The arbitration process itself is carried out by the reader/writer electronic circuitry. This may take the form of a dedicated controller, say an ASIC, (Application-Specific Integrated Circuit, or may more conveniently be a RISC-type (Reduced Instruction-Set Computer) microprocessor or micro-controller. The latter types are capable of being more easily updated to cope with new configurations of memory and data.

The minimum level of security that the Central Processing Unit will arbitrate requires the validation of a secret access code by the microprocessor in the Smart chip on the card. This is conveniently achieved by first interrogating the 'Smart' microprocessor chip embedded under the conventional ISO7816 part of the card. Access to this card is made only with knowledge of the correct 'password' or Personal Identification Number (PIN). Contained within the data structure of the Smart chip, as defined in ISO7816, is the 'key' to enable access to the memory embedded under the extra connection pads of the Improved Smart Card. The memory chip has a unique serial number, which is also programmed into the Smart chip during manufacture. Thus both numbers have to match before data transfer is validated.

Conveniently, the data stored in the memory on the smart card would usually be further encrypted by means of an algorithm based around both the serial numbers of the chips and a key known only to specific authorised users. The authorisation to decrypt may be in the form of dedicated computer software, purchased under licence, containing the second 'key' of this 'dual-key encryption' (Public-Private Key) method. This is in the same manner as is currently used to validate transactions over the Internet, especially financial transactions. Other methods of validation may also be used, such as PKI (Public Key Infrastructure) authentication.

For applications such as Electronic Books (E-books), Personal Audio Devices (PADs), including Talking books, and MP3-type Music Players, purchase of the appropriate reader also purchases a licence to use the media recorded on the card. In this case, the software 'key' for decryption is built-in to the operating firmware of said reader. The reader/writer in these types of application is not required to write data to the memory within the card, but is a read-only device. It does communicate with the 'Smart' chip to validate data transfer, but the 'key' data, obtained from the reader, is not written to the 'Smart' chip, merely compared with the internally stored 'key'. This comparison is an internal process within the 'Smart' chip that is inherent in the security of the ISO standard.

The stored data for devices such as E-books and MP3 Music Players would conveniently have, distributed within the data file, a small encrypted file containing the time and date of the creation of the file along with, say, details of the Artist/Author or other Intellectual Property holder. This file is completely transparent to the user, and is undetectable in normal use. If the data file (i.e. Book or Music) is copied, the hidden file is also copied and may be detected and decrypted by the appropriate software to prove that the file has been illegally transferred. This technique is sometimes called 'Digital Watermarking'.

For the above types of media, which may have a content that is the subject of Copyright, or Intellectual Property, the Improved Smart card offers a high degree of security for that Copyright. The card data for these types of media is written either at manufacture, or at point of sale, possibly by an EPOS (Electronic Point-of-Sale) system. Each time a new data file is written to the memory of the card, a record of this transaction is written into the 'Smart' chip in a write-once-only area of the chip. Thus a permanent record is available on the card of all transactions.

It is possible, for instance, for the record to be checked for, say, unauthorised (pirated) data, and the card invalidated and locked from further data transfers to/from the memory if this is detected. The card user must then approach the vendor to have

the card 'unlocked', possibly by the payment of due royalties. The data validation process takes place at the vendors' computer, but the reader/writer electronics are responsible for actually 'locking' the card currently situated in that reader/writer, on command from the validation authority.

'Pirating' from validated cards is also protected by including the serial number of the memory card, (used as an encryption 'key' in the card validation), in the 'Digital Watermarking' file encrypted within the Copyrighted data file. It is then possible to detect whether the file has been copied from one card to another, as the serial numbers will no longer match.

Thus the Copyright for Books, Music, Talking books and other forms of Intellectual Property, is protected to a greater degree than by currently available media, as a secure, permanent transaction record is available for validation.

With the increasing use of the Internet for all forms of communication and commerce, there is a corresponding need for faster data transfer across the Internet. The majority of data traffic is still dependant on Land-lines, which historically have been deliberately bandwidth-limited in order to maximise the number of speech channels available. This means that even with the fastest available modems, files of larger than 1 Megabyte still take an unacceptably long time to 'download'. Business customers often rent dual or multiple lines, or subscribe to ISDN lines of greater bandwidth in order to decrease data transfer times. Mobile telephones are similarly currently allotted too small a bandwidth for fast data transfer, as the allocated bandwidth was originally intended for speech only.

An emerging form of fast data transfer is appearing in the Satellite Television sector of the marketplace. In this method of Internet access, use is made of the fact that the majority of domestic usage of the Internet involves little data flow from the user to, say, an Internet service provider. The majority of the data traffic flow is from provider to user. This may be in the form of free or purchased software such as programs, multimedia or games, or, more recently, music or video files. These large

files are transmitted to the user, not by conventional methods, but by being transmitted via Satellites, together with Satellite TV programmes. This method gives vastly improved bandwidth capability, resulting in significantly shorter 'download' times. This method of Internet access is currently being offered as a part of the emerging 'Interactive Television' and 'Video-on-Demand' marketplaces, which seek to attract 'computer-illiterate' users, who do not own, or who do not wish to own, a Personal Computer, and who would otherwise not use the Internet.

Use is already made of existing 'Smart' cards in the Satellite receiver set-top boxes to ensure only validated customers are able to decrypt paid-for services. The decryption codes are altered on a regular basis, ensuring that users without a validated 'Smart' card will not be able to decrypt further programmes. The Improved Smart Card and associated reader/writer will enable the secure storage of all the decryption codes of all subscribed channels on one subscriber card, with validation able to be enacted via land-lines and updating of information via satellite. Further to this, it will allow the fast, secure transfer of sensitive data, such as financial details, with the validation 'private key' for dual-key encryption methods, or similar methods, embedded within the Smart chip.

The large amounts of memory available means it becomes practical to download large files and Copyrighted material, such as Music files, securely, and in an acceptably short time.

Reading and writing of data to a smart card follows a strict procedural path which controls access to the data. This is referred to as a protocol. The protocol prescribes not only data access, but also the electrical path of the data through the reader/writer for a given physical implementation of the smart card. The central processing unit, or arbitration means, implements the protocols relating to the control of the electrical path of the data through the reader/writer. Details of the data transfer protocols are now described:

Data transfer protocols.

For applications requiring a fast data transfer rate, such as, say, digital video, a more expensive type of memory and controller is required, to deliver parallel data at a fast data transfer rate via the extra port. For applications such as Text, Music or general data files, it is convenient to use a less expensive type of memory, utilising serial transfer of data. The transfer of data through the port is still many times faster than that through the ISO7816 port, because the protocols of that port historically require a very slow data transfer rate.

For applications requiring a greater degree of security, the Improved Smart Card may be in a form where physical access to the electrical connections of the memory embedded under the extra port is prevented. This is achieved by tri-stating, (i.e. switching to a high-impedance state), the connections to the card contact pads on the extra port. The connection is electrically made by the microprocessor in the 'Smart' chip, embedded under the ISO port, only after transaction validation by said 'Smart' chip.

For applications requiring less security, it is convenient to utilise less expensive integrated circuits that do not have internal connections between memory and 'Smart' chip within the card. In this case, data encryption techniques are used to further protect the data integrity, as previously described, once the interface has validated the transaction and unlocked the data transfer from the memory.

For all required degrees of security, the interface electronics must determine the required configuration of the extra port by interrogation of the 'Smart' chip in the ISO port of the reader/writer, again as previously described, by use of a 'PIN' number. Once communication with the 'Smart' chip is established, the first data stream is read from the 'Smart' chip by the interface electronics. Contained within this data stream, is the 'key' to unlock access to the other port, and details on the configuration of the pins of this extra port. Thus the reader/writer electronics is able to configure the appropriate pins on the extra port and establish the correct electrical

connections to commence communications across said extra port, for both parallel and serial configurations of said extra port.

In application where the reader/writer is to be attached to, or incorporated in, for instance a Personal Computer or similar device, a software computer programme is required to communicate with said reader/writer. This software takes the form of a 'Driver' type of programme, which is integrated, or 'installed' in the operating system of the host device. The software has embedded into it the 'private' key needed to decrypt information stored on the card in encrypted form. This is transparent to the user, the purchase of the interface and software driver licensing the decryption process. The 'Driver' programme is embedded in the firmware of devices such as E-books and Music Players.

For types of file where the stored data needs to be decrypted, or simply decoded or translated from one file structure to another, 'applications' programmes may be required. These may be used, for example, to convert Music Information stored in MP3 (MPEG 2, Level 3) compression format. The MP3 format is a recent, complicated compression technique and there is room for error in interpreting the structure of the compressed data and in assigning a file structure for the stored data. Different system designers have interpreted the MP3 specifications in different ways, resulting in Music files that cannot be 'played' on other MP3 systems. A method of avoiding this problem is to have an Applications program that is capable of applying all the different decoding criteria to the recorded data. When the respective Music file is recorded, it is recorded with a small 'header' that contains information about which type of file structure the recorded music has. The Applications programme is then able to utilise the correct decoding criteria for the recorded Music.

This technique of using header information is also used by the Improved Smart reader/writer to determine the type of memory contained on the Improved Smart Card, and hence to configure the interface electronics accordingly.

Adaptor Card

The reader/writer is also capable of being used as an adaptor platform to convert various other interface types to be read via the contact pins of the reader/writer. This may be conveniently achieved by use of a 'dummy' type of Improved Smart Card to 'map' the different pin configurations through the sixteen pins of the reader/writer. This card has no memory function itself, but may conveniently contain a 'Smart' chip which will serve a 'gatekeeper' function, protecting access across the adaptor by the use of password 'keys' or PINs.

The adaptor card also contains a dedicated integrated circuit, possibly an ASIC, or a RISC device, which converts the relevant protocols from the attached media or peripheral device to those appropriate to the Improved Smart Card interface. Power for the adaptor card is derived from the reader/writer connections, which normally power the Improved Smart Card itself, when said adaptor card is inserted into the reader/writer.

Thus other input means, both memory means and external peripheral means, may be used in a device that has an Improved Smart Card reader/writer, with the added benefit of password-controlled access. As the other input means do not have inherent security, the data stored on them is assumed not to be at risk. The need for password-control in this type of application is primarily to prevent unauthorised transfer of data on to the Improved Smart Card reader/writer's host device, i.e. no unauthorised downloading from, say, the internet via a modem. In this example, the modem may, conveniently, have a serial port which may be 'mapped' on to the adaptor card.

Thus, for instance, by use of a PCMCIA-card-controller type of dedicated Integrated Circuit, a PCMCIA card or cards may be read via the Improved Smart Card interface.

Similarly by use of a SmartMedia card-controller type of dedicated Integrated Circuit, a SmartMedia card or cards may be read via the Improved Smart Card interface.

Also, by use of card-controller type of an MMC (Multi-Media Card) dedicated Integrated Circuit, an MMC card or cards may be read via the Improved Smart Card interface.

Such serial devices may, for instance, conform to the RS232 standard, or may conform to the USB (Universal Serial Bus) standard.

Such parallel devices may, for instance, conform to the Centronics- type parallel-port configuration, or conform to the IEEE488 instrumentation bus standard.

Conveniently, with the appropriate dedicated conversion Integrated Circuit and connections, any serial or parallel type of data from any peripheral device or media type, is capable of being accessed via the Improved Smart Card reader/writer.

It is possible to replace all other types of interface means to external memory and peripheral devices in a Personal Computer, Laptop Computer, Notebook computer, Palmtop Computer, Personal Digital Assistant, or other similar device, by a multiple of Improved Smart Card type reader/writers. This would result in a unification of all the diverse types of interfaces into possibly the smallest practical and convenient secure form, thus providing a 'Global System for Information Interchange'.

Table 3 below gives examples of mappings of different serial protocols such as may be used by the adaptor card. This table gives examples of how different serial protocols may be mapped on to the improved smart card extra port when said extra port is configured as a serial port. Examples are given of MultiMediaCard MMC and Serial Peripheral Interface SPI bus standards. Other serial portocols may be mapped in a similar manner.

In summary, the physical reader/writer comprises

- A physical card holder with provision for a card conforming to ISO7816 to be inserted into a slot in said card holder, and with supporting material for sets of electrical contacts.
- A set of sixteen electrical contact pins, arranged such that said contact pins are in alignment with the sixteen contact pads on the Improved Smart Card when the card is pushed fully home into the locating slot.
- A set of two further contact pins arranged such that said two contact pins make contact with the extended 'Ground' contact pad running across the centre of said Improved Smart Card contact pad area. One contact pin is positioned in the physical centre of the conventional eight-pin interface described in ISO7816. The second pin is positioned in the physical centre of the additional eight-pin interface that constitutes the 'Improved' part of said Improved Smart Card.
- An additional pair of electrical contacts arranged in the form of a switch. Said switch contacts are normally 'open', i.e. not in contact, with no card inserted in the interface. When a card is inserted and pushed fully home, the switch contacts are closed together, making electrical contact.

In summary, the arbitration means for enabling secure transfer of data to and from a smart card comprise:

- A Central Processing Unit comprising, conveniently, electronic circuitry to arbitrate and control the flow of data through said Interface.
- Electrical connection from the ISO7816 specified physical eight-pin contact pad to said Central Processing Unit.
- Electrical connection from the Improved Smart Card physical eight-pin contact pad to said Central Processing Unit.
- Electrical connection from said Central Processing Unit to, conveniently, a parallel port, or USB (Universal Serial Bus) port connection of a Personal Computer, or any other means of writing/reading to said card.

The improved smart card can be used for many purposes including as a secure replacement for magnetic storage devices, solid state memory devices, and optical and rotational storage devices. The improved smart card can be used to store many different types of application including computer programs, games programs, music files, multimedia files, video files and personal files including medical data, personal fitness data, passport data, driving licence data, library data, and machine control data.

Tabl 1

Electrical Connections illustrated in Figure 2 for parallel configuration

The Electrical connections are: -

Pin 1 - Vcc - typically +5 Volts.

Pin 2 - RST - Reset.

Pin 3 - CLK - Data Clock.

Pin 4 - NC - Not Connected - Reserved for future use.

Pin 5 - GND - Ground - 0 Volts.

Pin 6 - Vpp - Programming Voltage.

Pin 7 - I /O - Input / Output.

Pin 8 - NC - Not Connected - Reserved for future use.

Pin 9 - Data Bit 1 - Parallel Data - Least Significant Bit - LSB.

Pin 10 - Data Bit 2 - Parallel Data.

Pin 11 - Data Bit 3 - Parallel Data.

Pin 12 - Data Bit 4 - Parallel Data.

Pin 13 - Data Bit 5 - Parallel Data.

Pin 14 - Data Bit 6 - Parallel Data.

Pin 15 - Data Bit 7 - Parallel Data.

Pin 16 - Data Bit 8 - Parallel Data - Most Significant Bit - MSB.

Pin 'a' - Ground - Electrically and Mechanically Connected to Pin 5.

Pin 'b' - Ground - Electrically and Mechanically Connected to Pin 5.

Table 2

Electrical connections for serial configuraiton

Pin 1 - Vcc - typically +5 Volts.

Pin 2 - RST - Reset.

Pin 3 - CLK - Data Clock.

Pin 4 - NC - Reserved for future use.

Pin 5 - GND - Ground - 0 Volts.

Pin 6 - Vpp - Programming Voltage.

Pin 7 - I /O - Input / Output.

Pin 8 - NC - Reserved for future use.

Pin 9 - NC - Reserved for future use.

Pin 10 - CTRL - Command & Control.

Pin 11 - CLK - Clock.

Pin 12 - NC - Reserved for future use.

Pin 13 - NC - Reserved for future use.

Pin 14 - MCS - Memory / Chip Select.

Pin 15 - I/O - Input / Output.

Pin 16 - NC - Reserved for future use

Pin 'a' - Ground - Electrically and Mechanically Connected to Pin 5.

Pin 'b' - Ground - Electrically and Mechanically Connected to Pin 5.

Table 3

Examples of mapping different serial protocols (xtra port configured to serial port)

	Serial Improved Smart	MMC	SPI
Pin 9	NC	NC	NC
Pin 10	CTRL	CMD (Command)	Data In
Pin 11	CLK	CLK	CLK
Pin 12	NC	NC	NC
Pin 13	NC	NC	NC
Pin 14	MCS	RSV (Always 1)	ChipSelect
Pin 15	I/O	DAT (Data I/O)	Data Out
Pin 16	NC	NC	NC